# Space Weather Technical Forecast

Issued on Thursday, 04 January 2024 at 01:11 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

**Space Weather Forecast Headline: Further M-flares likely from AR3536 with a slight chance of X-flares.**

**Analysis of Space Weather Activity over past 24 hours**

**Solar Activity:** Activity has been low with largest flare being a C2.9 flare from AR3536 peaking at 03/1017, this continues to be the main region of note. The penumbra of the two previously separated main spots of AR3536 have now joined up, creating a larger asymmetric region of mixed polarity, containing a weak delta spot. The overall magnetic structure remains relatively complex with a number small spots of varying polarities following this main spot. There are four sunspot regions now on the disc, but the remaining spots are all smaller and simpler at this time.

A number of CMEs were visible in imagery, however these have all been assessed as being off the Earth-Sun line with no Earth-directed CMEs occurring.

**Solar Wind / Geomagnetic Activity:** Solar winds were indicative of a weak fast wind from CH86/-, followed by glancing blows from two CMEs, the first, believed to be from a filament eruption on 31 Dec, arrived at 03/0450 UTC and the second from the X5.0 flare on 31 Dec arrived around 03/1420 UTC. Speeds varied between 380-450km/s until around 1420UTC, but did increase abruptly to peak at 478km/s at 03/0717 UTC after the first CME. After arrival of the second CME at around 03/1420UTC speeds have largely varied between 450-490km/s, but did peak at 501 km/s at 1900UTC. Density was largely at, or below average, but increased to above average levels for a few hours after the arrivals of both CMEs, peaking at 18ppcc at 03/1533 UTC, before returning to average levels by the end of the period. Interplanetary Magnetic Field (IMF), Bt, initially varied between weak and moderate levels (5-8nT), but increased to peak 12nT at 03/0517 UTC, before declining to weak levels until the arrival of the second CME, at which point it increased to mostly moderate levels for the duration of the period. The north-south component, Bz varied weakly between northward and southward directions at first, but reached moderately positive levels briefly, following the first CME arrival, then varied weakly between northwards and southwards directions for the rest of the period. Phi angle was generally negative (towards the Sun). Geomagnetic activity was Quiet to Unsettled (Kp1-3).

**Energetic Particles / Solar Radiation:** GOES16 high energy (greater than 10MeV) proton flux has been on an increasing trend, with the >10MeV Proton just above the S1/Minor Storm threshold at time of issue. GOES16 high energy (greater than 2MeV) electron flux ranged was mainly at background. The 24-hour fluence was below Active throughout. The 04/0000 UTC observation was 2.84e6 integrated pfu.

**Four-Day Space Weather Forecast Summary**

**Solar Activity:** Despite the low flare activity over the past 24 hours, there remains a likelihood of further isolated M-flares from AR3536 and a slight chance of an X-class flare.

**Solar Wind / Geomagnetic Activity:** Despite two CMEs giving glancing blows on the 03 Jan, minimal geomagnetic effects were observed. Otherwise, fast winds from CH86/-, with current speeds of 450-480km/s are expected to continue at first day 1 (04 Jan), gradually easing later in the day. Wind speeds are then expected to continue to ease towards background levels through

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Days 2-3 (05-06 Jan). No other enhancements are forecast. Quiet geomagnetic activity is expected for much of the period, with a decreasing chance of isolated Unsettled intervals.

**Energetic Particles / Solar Radiation:** GOES16 high energy proton flux has risen just above the S1/Minor Storm threshold in response to recent significant flare activity. Proton flux levels are expected to continue to exceed S1/Minor storm levels on day 1 (04 Jan) with a chance of continuing into Day 2 (03 Jan), then a slight chance on subsequent days, dependent on any further notable flares occurring. GOES16 high energy electron flux is likely to remain near background, perhaps briefly rising to Moderate later in the period, with the associated fluence remaining below the Active level.

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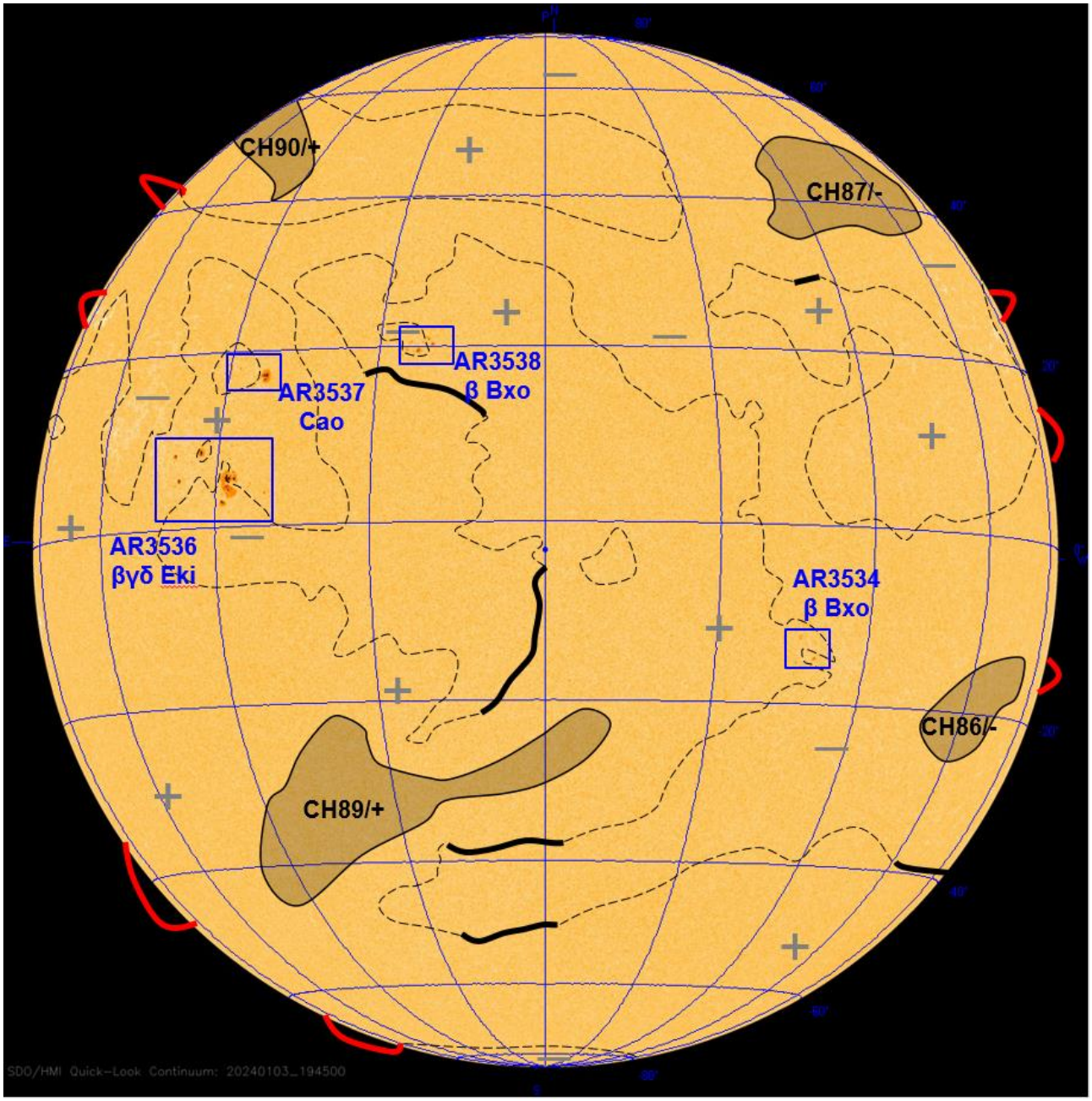
**Figure 1. Solar Analysis Valid 03/2000UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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## Geomagnetic Storms:

Two CMEs gave minor glancing impacts on Earth on the 03 Jan. The first, believed to be from a filament eruption on 31 Dec, arrived at 0450UTC and the second from the X5.0 flare on 31 Dec arrived around 1420UTC. However despite these CME arrivals, minimal geomagnetic effects have been observed.

Otherwise, fast winds from CH86/-, with current speeds of 450-480km/s are expected to continue at first day 1 (04 Jan), gradually easing later in the day. Wind speeds are then expected to continue to ease towards background levels through Days 2-3 (05-06 Jan).

Quiet geomagnetic activity is expected for much of the period, with a decreasing risk chance of isolated unsettled periods.

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 1 | 1 | 1 | 1 |
| Strong | G3 | No | 1 | 1 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

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## Radio Blackouts - X-Ray Flares:

Moderate activity is expected to continue with further M-flares likely from AR3536 and a slight chance of X-class flares.

There are four sunspot regions now on the disc, with AR3535 rotating off the western limb and AR3534 re-emerging after appearing to dissipate for a time. The new region in the North-eastern limb has now been numbered AR3538, but the most notable group remains AR3536 which was the source of an X5.0 flare on 31 Dec. The penumbra of the two previously separated main spots have now joined up, creating a larger asymmetric region of mixed polarity, containing a weak delta spot. The overall magnetic structure remains relatively complex with a number small spots of varying polarities following this main spot. The remaining spots are all smaller and simpler at this time.

Activity has been low with largest flare being a C2.9 flare from AR3536 peaking at 03/1017. Despite the low flare activity over the past 24 hours, there remains a likelihood of further isolated M-flares from AR3536 and a slight chance of an X-class flare.

| X Ray Flares | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability | | | (%) | (%) | (%) | (%) |
| Active | R1-R2 M Class | No | 55 | 55 | 55 | 55 |
| Very Active | R3 to R5 X Class | No | 10 | 10 | 10 | 10 |

**Figure 2: GOES-16/18 X-ray flux:**

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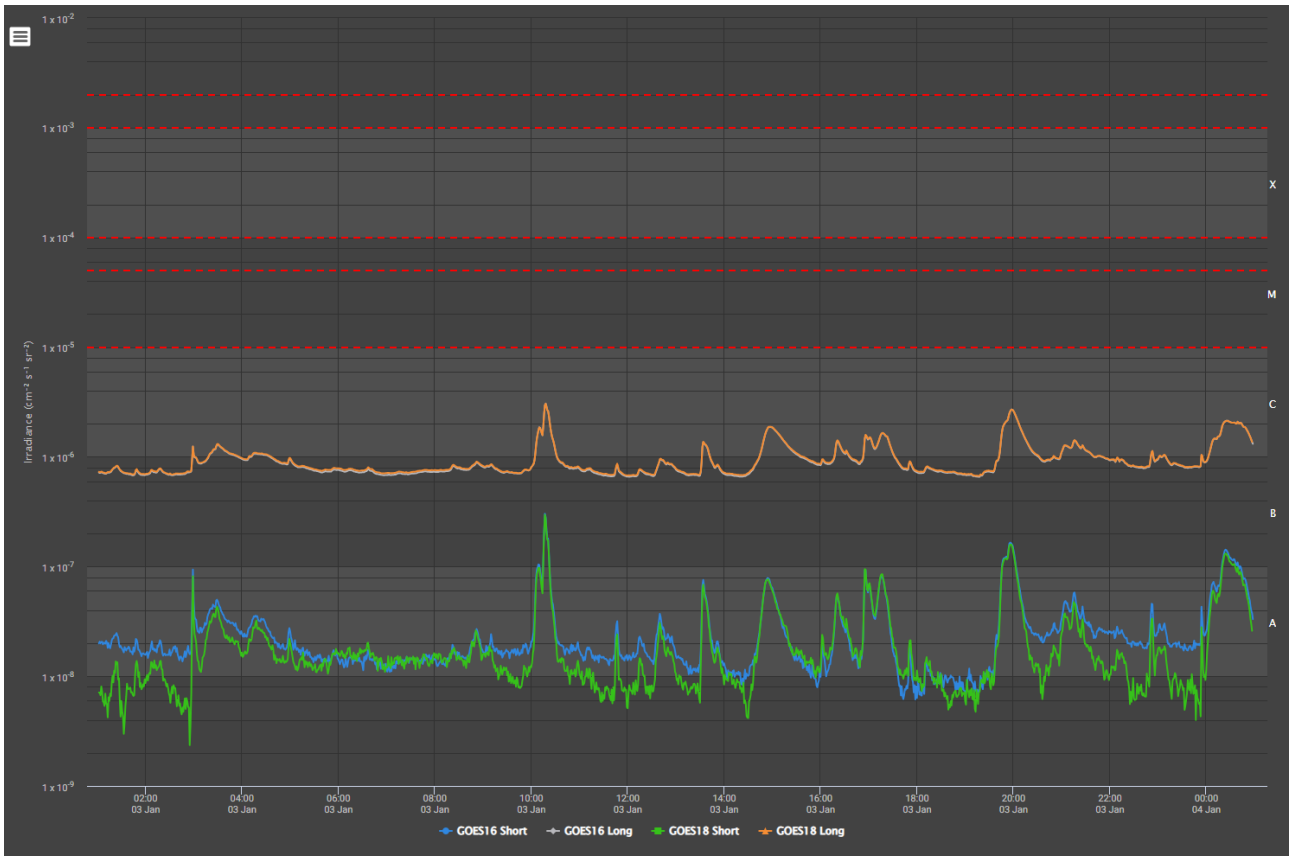


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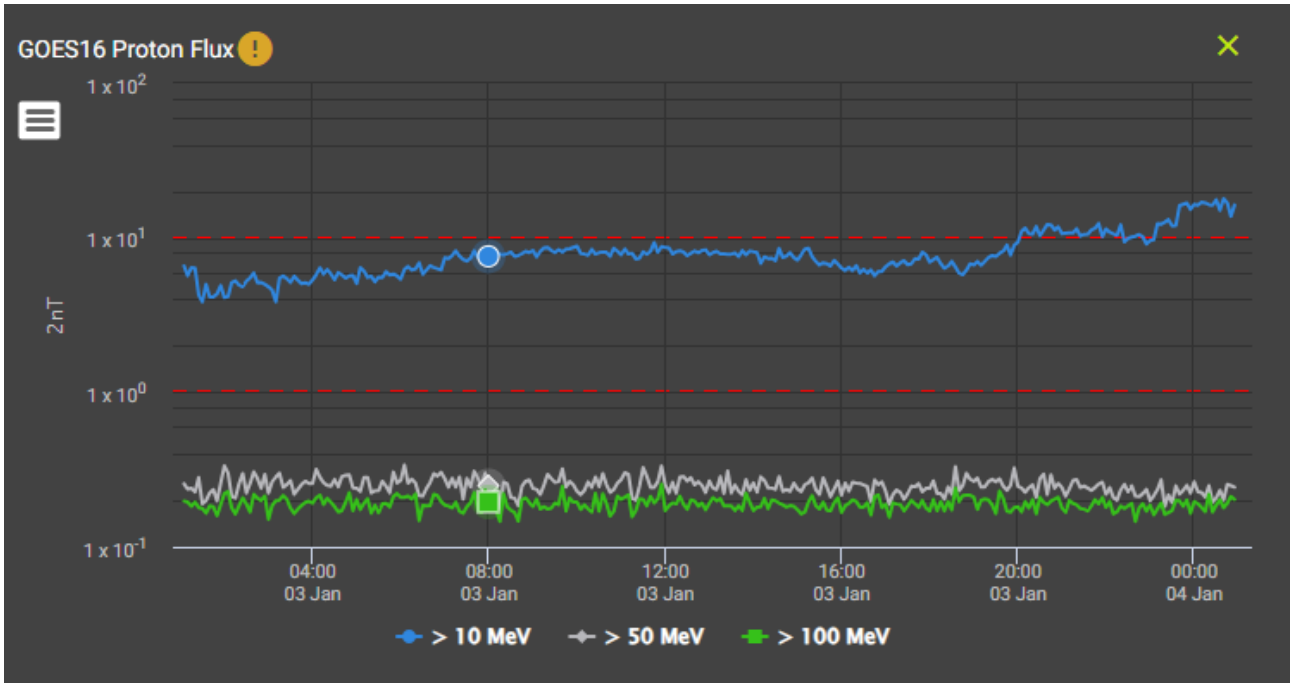
## Solar Radiation Storms - (High Energy Protons):

GOES16 high energy (greater than 10MeV) proton flux has been on an increasing trend, with the >10MeV Proton flux just above the S1/Minor Storm threshold at time of issue. This is the result of the recent large flares from AR3536. It is expected the >10MeV proton flux will continue to be just above the S1/Minor Storm threshold at first on Day 1 (04 Jan), before slowly dropping towards background or slightly elevated, due to uncertainty into the reduction rate of the proton flux, there is a chance the S1/Minor storm threshold could also be exceeded initially for Day 2 (05 Jan). Any further significant flares, primarily from this region, will bring a risk of further increases in the observed proton flux. This gives a slight chance of reaching the S1 Minor Storm level from Day 3 (06 Jan) onwards, perhaps slightly increasing on day 4 (07 Dec) as the region moves further west on the disc and into a more central location.

| Radiation Storms Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | Yes | 100 | 25 | 10 | 15 |
| **Very Active** | **≥ S3 *** | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

**Figure 3: GOES16 Proton Flux:**

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## High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as observed by GOES-16 continues to persist at mostly background levels. The fast wind of CH86/- is weaker than originally expected, with only minimal geomagnetic activity observed. Furthermore, no significant CME enhancements have been observed with the two glancing blows only giving unsettled (Kp3) geomagnetic activity for a time. With no further CME impacts expected, mainly background flux is predicted to continue with a chance of reaching Moderate during periods of diurnal maximum.

The associated 24 hour fluence is forecast to persist at background, although a rising trend is likely from late Day 1 (04 Jan), as solar winds ease. This is supported by REFM which is currently giving good guidance.

| GEO Electron Environment<br>Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ 2 MeV ≥ $1x10^8$** | No | 1 | 1 | 1 | 1 |
| **Very Active** | **≥ 2 MeV ≥ $1x10^9$** | No | 1 | 1 | 1 | 1 |

**Figure 4 GOES16 >2MeV Electron Flux and MOSWOC REFM with recurrence:**

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